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Reprint from
SURGERY, GYNECOLOGY AND OBSTETRICS
February, 1914, pages 196-202

A STUDY OF THE COMPARATIVE VALUE OF FUNCTIONAL TESTS IN THE SURGICAL DISEASES OF THE KIDNEY SECONDARY TO OBSTRUCTION IN THE LOWER URINARY TRACT

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In our previous communications[2] on the subject of renal function attention has been called to the value of phthalein in affording an index to the renal functional capacity in the changes resulting from obstruction in the lower urinary tract. It was pointed out that such patients are frequently the subject of hydronephrosis, pyelonephritis, pyonephrosis, pressure atrophy, and resulting changes in functional activity, and that the urine output, urea, and total solids might be practically normal and yet the patient be on the verge of renal failure which would surely be precipitated by any radical surgical interference. The phthalein was shown to be of value in all these cases and to allow of differentiation between those cases with severe renal damage and those in which the renal involvement was slight. It was further shown that the marked improvement of the renal condition and operative risk which followed the adoption of Young's preliminary treatment (constant catheter and forcing of water) was the result to a large extent of the improvement of the renal functional capacity. It was claimed that the test made it possible to determine the cases suitable or unsuitable for operation and also to determine in any given case the most propitious time for surgical intervention.

In this study a number of tests have been utilized in order to determine if any individual test or any combination of tests furnishes information other than that derived from the use of phthalein. The number of functional tests has increased to such an extent that it is essential to determine which can be discarded without loss. Only through familiarity with the reliability, value, limitations, peculiarities, and the significance of the findings of each test in the various types of disease is the most profitable selection of tests made possible.

Renal functional capacity is usually ascertained in one of two ways: (1) Tests of excretory capacity through the quantitative determinations of the secretion of various substances in the urine,— dyes, methylene blue, indigo-carmin, rosaniline, and phthalein; other chemicals, potassium iodide, lactose, salicylates, sodium chloride, urea, sugar following phloridzin, and the enzyme, diastase. (2) Tests of retention through the determination of the concentration of certain substances in the blood, ions — through electrical conductivity, molecules and ions — through cryoscopy, and urea, total incoagulable nitrogen and cholesterin. Choice has been made of what has appeared to be the most important representatives of these groups; viz., of the first, phthalein, lactose, diastase, and urea; of the second, cryoscopy and blood urea.

THE TESTS EMPLOYED AND THEIR TECHNIQUE

1. The *phthalein* was used according to the usual technique.

2. *Lactose* was employed according to Schlayer's technique:[3] 2.5 gms. of lactose are dissolved in 25 ccm. of freshly distilled water, placed in a 50 ccm. Erlenmeyer flask stoppered with cotton. This is pasteurized for 4 hours on four successive days between 75°–80° C., and is injected intravenously, the number of hours necessary for excretion being determined. Nylander's and Fehling's tests were used to demonstrate the presence or absence of sugar. No quantitative polarimetric determinations which are advised by Schlayer were utilized, since only in a small proportion of cases did glycosuria occur.

3. *Diastase.* Diastase was introduced into functional renal work by Wohlgemuth[4] for

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[2] Rowntree and Geraghty: J. Phar. & Exp. Therap., 1910, i, 579; Arch. Internal Med., 1912, ix, 284.

[3] Schlayer and Takayasu: Deutsche Arch. f. klin. Med.

[4] Wohlgemuth: Ztschr. f. Urol., 1911, v, 801.

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determining the relative functional capacity of the two kidneys. A modification of this method was devised by us to make the test adaptable for determining total renal functional capacity. The technique which we employed was elaborated in conjunction with Dr. Thomas R. Brown,[1] who has demonstrated with it that the total daily output in urine is fairly constant. The technique employed was as follows: One-fifth of the twenty-four hour urine collected under toluol was neutralized and diluted to 1 L. By means of a graduated 2 ccm. pipette, decreasing amounts of urine were placed in a series of twelve tubes (arranged in a rack) as follows: 1.8, 1.6, 1.4, 1.2, 1, 0.8, 0.6, 0.4 ccm. Ten ccm. of the diluted urine was further diluted to 20 ccm. and of this decreasing amounts placed in the remaining tubes of the series as follows: 0.4, 0.2, 0.1, 0.05 ccm. To each tube was added sufficient 1 per cent NaCl solution to bring the total volume in each tube to 2 ccm. Two ccm. of a 0.1 per cent freshly prepared soluble starch solution was added to each tube. The rack with the tubes was placed in a water-bath at 38° C. for a half-hour, then transferred to cold water for 3 minutes. Sufficient 1/50 N iodine solution was added drop by drop in amounts sufficient to elicit a permanent color. The occurrence of blue or violet shows incomplete digestion, while the last tube without the violet color indicates the diastatic activity of the urine and from it is calculated. The diastatic activity is expressed by $d\,\frac{30^{\circ}}{30'}$ which represents the number of ccm. of 0.1 per cent starch solution capable of being digested at 38° C. in 30 minutes by 1 ccm. of the urine as originally diluted.

The *urea* content of the twenty-four hour specimens of urine was determined by the Doremus and the Marshall[2] methods, the results of each being given.

The principle of Marshall's method consists in the conversion of the urea into ammonium carbonate by means of an enzyme, urease, present in an extract of the soy bean, and the titration with standard hydrochloric acid and methyl orange. "Two 5 ccm. portions of urine are measured into flasks of 200–300 ccm. capacity and diluted with distilled water to about 100–125 ccm. Two ccm. of the enzyme solution are added to one flask, a few drops of toluol to each and the solutions allowed to remain, well stoppered, at room temperature over night. The fluid in each flask is titrated with 0.1 NHCl and methyl orange. The amount of hydrochloric acid required for neutralization of the contents of the flask containing the urine and enzyme solution less the amount required for neutralization of 5 ccm. urine alone and 2 ccm. enzyme solution alone corresponds to the urea originally present in the urine. This value multiplied by 0.6 gives the number of grams of urea per liter of urine.

The freezing point of serum was made in the ordinary way, utilizing the Beckmann apparatus, 25 to 50 ccm. of blood usually being taken from the patient.

The blood urea was determined according to Marshall's method[3] which is as follows: Two equal portions of the serum (3 ccm. or 5 ccm.) are measured into two small test tubes, 1 ccm. of the enzyme solution added to one, toluol to each, and the tubes allowed to remain over night. The contents of each tube are washed into tall cylinders, alcohol and sodium carbonate added, and the ammonia removed by means of a strong air current. The ammonia is collected in flasks containing 25 ccm. N/50 hydrochloric acid. When all the ammonia has been driven over, the excess of acid in the flasks is titrated with N/50 sodium hydroxide and sodium alizarin sulphonate. The amount of hydrochloric acid required to neutralize the ammonia from the serum and enzyme solution less the amount required for the ammonia from the serum alone represents the urea present in the amount of serum taken.

THE RESULTS OBTAINED

In the following table are presented data relating to 43 cases, in the majority of which a combination of all of the tests mentioned has been utilized. The cases for the most part exhibited varying degrees of urinary obstruction.

Our earlier views in regard to the value of the phthalein test in this type of case require no revision. As an index of the total renal function it has proven uniformly accurate and reliable.

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[1] To appear shortly.

[2] Marshall: J. Biol. Chem., 1913, xiv, 283.

[3] To appear in an early number of Journal Biological Chemistry.

The lactose test has been employed in 22 cases. In all of the earlier cases the urine was collected for 4 hours and each 2 hours thereafter up to 12 hours following Schlayer's technique. In only two cases, Nos. 8 and 35, was a positive test for sugar obtained. In No. 6, a case of tabes, with 200 ccm. residual urine, the phthalein showed practically a normal renal function, while clinical findings showed no evidence of renal disease. However, no lactose was obtained in this case. In Case 10, with hypertrophied prostate and normal renal function as indicated by phthalein, no lactose was excreted. This patient was in good clinical condition, and successful prostatectomy was performed. In four later cases in which following the lactose injection the urine was collected at hourly intervals, a trace of lactose was obtained in some of the periods. The renal function in these cases was more impaired than in many of the earlier ones in which the first collection was for 4 hours. It is not improbable that if the urine had been collected at hourly intervals in these earlier cases, a positive test might have been obtained in some of the hourly specimens in many of the cases which showed a negative finding with the technique employed. In two of the four cases mentioned above the excretion was complete within 4 hours. One of these, however, had a severe grade of renal involvement.

The majority of the patients in this group were on forced water and excreted large quantities of urine. Marked dilution resulting from this polyuria may help to explain the failure to detect lactose where traces only were excreted. The failure on the part of lactose to appear in the urine is in keeping with our earlier experiences with phloridzin in this type of renal disease. Phloridzin was used in eight patients suffering from renal changes secondary to prostate hypertrophy but in not a single instance was sugar recovered. Further observations were therefore not made.

The lactose test in this type of case has proven of but little value from a diagnostic standpoint, and of no value in relation to prognosis.

Twenty-seven diastase estimations were made in 24 cases. We have considered the normal diastatic activity of the diluted urine as $d\,\frac{38^\circ}{30'}=5.0$.

In some cases with severe renal damage, the diastase content was normal. A striking example of this is Case 5, in which the phthalein and the clinical condition indicated severe renal impairment. The diastase value was $d\,\frac{38^\circ}{30'}=10$. This patient died of hæmorrhage following prostatectomy, and at autopsy a well marked chronic diffuse nephritis with chronic bilateral pyelonephritis and a moderate grade of hydronephrosis was discovered. One kidney was one-fourth the size of the other, the larger kidney weighing 170 grams. The character of the lesions was similar in both kidneys. On the other hand, in another case, Case 18, in slight hæmaturia with advanced double polycystic disease of the kidneys, with a blood pressure of over 200 mm., a trace of phthalein in two hours, and a freezing point of $-.70^\circ$, the diastase was only slightly reduced being $d\,\frac{38^\circ}{30'}=3.3$. This patient died a few weeks after leaving the hospital, without the cause of death being ascertained.

In Case 33 in which the phthalein and clinical findings showed only slight renal impairment, the diastase was markedly decreased, $d\,\frac{38^\circ}{30'}=1.7$.

In the majority of instances of disease a decreased diastatic activity is present, but no constant or definite relationship between the diastatic activity and the true renal function as shown by phthalein and clinical findings exists. Where, however, a complete absence of diastase in the urine occurs, it apparently indicates a bad prognosis. Two cases, Nos. 7 and 43, with severe renal impairment as shown by excretory tests and the presence of marked cumulative phenomena, showed no diastase, and death occurred within two weeks in Case 43 and within one month in the other. Autopsies were obtained in each of these cases and revealed advanced renal disease.

Urea estimations of the twenty-four hour output were made in twenty-two cases.

	Surg. No. Case	Name	Date admitted	Diagnosis	B. P.	Date	Phthalein			Diastase $d\frac{38^\circ}{30'}$	24 Hour Amount ccm.	Urine Urea grams	Cryoscopy	Lactose	Remarks
							Appear Minutes	1st Hr.	2d Hr.						
1	30731	M. L. B. 60 years	11/12/12	Enlarged prostate Cystitis			17	9%	13%	5.0	3100			Negative	Prostatectomy. Good recovery.
2	30765	W. H. A. 70 years	11/12/12	Hypertrophy prostate			15	17%	20%					Negative	Prostatectomy. Recovery.
3	30901	Dr. J. K. 63 years	11/16/12	Hypertrophy prostate	185	11/4/12	7	22%	5%					Negative	Prostatectomy. Recovery.
4	30919	J. S. J. 59 years	11/19/12 1/2/13	Hypertrophy prostate Chr. nephritis	220	11/16/12 1/1/13 1/21/13 1/23/13	14 62? 14 15	6% 10% 21% 17%	8% 20% 20% 30%				.62 1/2/13	Negative 1/2/13	Prostatectomy. Recovery.
5	30928	Wm. W. 69 years	11/19/12 11/30/12	Enlarged prostate Pyelonephritis	204	11/17/12 11/30/12	30 20	trace 15%	5% 10%	11/21/12 10.0	2900		.59 11/21/12	Negative 11/20/12	Prostatectomy. Died hæmorrhage.
6	30918	Wm. C. 55 years	11/16/12 11/24/12	Tabes 200 ccm. resid. urine	188	11/16/12 11/24/12	11 15	45% 48%	11% 12%	2.5	1400			Negative 11/20/12	No operation.
7	30932	G. F. 17 years	11/18/12 11/24/12 1/27/13 2/7/13	Double hydronephrosis Congenital valves Prostatic urethra		11/18/12	? ? ? ?	trace trace trace trace	5% trace 3% 3%	11/22/12 2.0 2/7/13 0	3340 2050	5.0 14.0	.61 11/20/12 .63 1/27/13 .66 2/7/13	Negative 11/20/12	Several diastase estimations of urine between 2/6-12/13 all same. Blood urea, 1.332 gms. per liter. Died pneumonia.
8	30962	C. W. 64 years	11/21/12 12/7/12	Hypertrophy prostate Operation	Put	11/21/12 11/24/12 on forced	22 13 water.	32% 25% Toxic	16% 35%				.55 11/22/12 .48 12/7/12 .54 12/12/12	4 hrs.[1]	Prostatectomy. Recovery.
9	30990	C. R. 80 years	11/26/12 12/9/12 1/1/13 3/18/13	Hypertrophy prostate Cystitis Pyelonephritis. Very weak Condition bad	170	11/27/12 12/9/12 1/1/13	22 64? 27	trace 5% 17%	5% 6% 15%	2.0 1 7	2980 3/11/13 1580	20.8 18.1 15.3	.57 1/2/13		Prostatectomy. Recovery.
10	30997	J. C. 62 years		Hypertrophy prostate	165	11/27/13	18	42%	20%					Negative 11/27/12	Prostatectomy. Recovery.
11	31028	F. E. 58 years	12/3/12 12/9/12	Hypertrophy prostate Arteriosclerosis	225	12/3/12	12	30%	20%	12/7/12 5.0	3400 12/6/12	10.2	.57 12/5/12	Negative 12/5/12	Prostatectomy. Recovery.
12	31027	J. B. 34 years	12/3/12	Nephroptosis, left	144	12/3/12	5½	48%	17%				.58 12/5/12	Negative 12/5/12	Suspension. Recovery.
13	31029	S. B. 77 years	12/3/12	Hypertrophy prostate Arteriosclerosis	220	12/3/12	12	28%	10%	12/4/12 2.5	2300 12/3/12	15.8	.51 12/7/12	Negative 12/5/12	Prostatectomy. Died broncho-pneumonia.
14	31039	M. E. C. 57 years	12/4/12	Hypertrophy prostate		12/4/12	15	17%	14%				.53 12/5/12		Prostatectomy. Recovery.
15	31059	Jos. P. 75 years	12/6/12	Hypertrophy prostate Ves. calculi Suprapubic drainage		12/7/12 1/1/13 1/21/13	32 62 14	7% 10% 24%	12% 20% 20%	12/13/12 2.5	3220 12/12/12		.60 12/12/12 .71 1/2/13 .59 1/23/13	Negative 1/23/13	Prostatectomy, 1/23/12. Died suddenly after going home.
16	31164	N. C. 75 years	12/23/12	Cancer bladder with partial retention.		12/23/12	7	22%	15%				.51 12/23/12		No operation.
17	31214	E. J. 60 years	1/1/13 1/7/13	Arteriosclerosis, no retention of urine Chr. nephritis	200	1/1/13	13	10%	9%	1/8/13 5.0	1625 1/7/13 2200 1/2/13 2760 1/3/13	17.9	.59 .56	Negative 1/23/13	No operation.

[1] Not quantitative test. 11/22/12.

18	31225	D. M. D. 65 years	1/2/13 1/8/13	Double polycystic kidneys	high	1/1/13	20	trace	trace	1/8/13 3.3	2650	18.5	.70 1/2/13		Died suddenly a few weeks later. No autopsy.
19	31249	J. S. 53 years	1/4/13	Hypertrophy prostate		1/4/13	0	34%	14%				.56 1/9/13		Prostatectomy. Recovery.
20	31313	L. F. 72 years	1/15/13	Hypertrophy prostate Bad heart condition		1/15/13 1/21/13	16 10	17% 17%	14% 15%				.56 1/16/13		Prostatectomy. Recovery.
21	29252	L. R. 45 years	1/18/13	Bilateral pyonephrosis Condition bad		1/18/13	35	trace	trace				.61 1/20/13		No operation.
22	31399	J. T. C. 74 years	2/2/13	Hypertrophy prostate		2/2/13	23	7%	1%				.58 2/1/13		Prostatectomy. Recovery.
23	31573	S. B. R. 42 years	2/22/13	Contracture vesical neck		2/22/13	10	45%	13%		3/10/13 1580	15.3	.54 2/24/13		Punch. Recovery.
24	31553	Col. F. M. 72 years	2/20/13	Cancer prostate Paralysis, Myocarditis		2/20/13 3/6/13	13 12	30% 41%	19% 17%	2/28/13 2.5	1560 2/27/13	11.7 10.4	.54 2/26/13		Prostatectomy, 3/7/13. Recovery.
25	31592	Wm. L. 63 years	2/25/13	Hypertrophy prostate						10.0	2380	19.0 15.8	.54 2/26/13		Prostatectomy, 2/28/13. Recovery.
26	31546	Gen. J. S. 71 years	2/19/13	Chr. cystitis Contracted bladder	140	2/23/13 3/6/13	6 10	20% 26%	15% 15%	2/28/13 3.3	1220 2/27/13	19.5 15.9			No operation.
27	31593	L. V. M. 69 years	2/26 13	Hypertrophy prostate Acute double pyelonephritis		3/3/13	10	22%	19%	3/5/13 3.3	830 3/2/13	9.5 8.7	.60 3/1/13		Prostatectomy, 3, [illegible] Blood urea, 0.660 gms per liter. Died.
28	31620	Col. C. W. 75 years	3/1/13	Hypertrophy prostate		3/2/13 3/4/13 3/6/13	10 11 10	22% 30% 38%	17% 18% 28%	3/5/13 2.5	5980 3/5/13	44.8 26.4	.50 3/4/13		Prostatectomy, 3/7/13. Recovery.
29	31619	Dr. A. H. L. 72 years	3/1/13	Cancer prostate		3/3/13	13	27%	10%				.55 3/4/13		Prostatectomy, 3/5/13. Blood urea, .426 gms. per liter. Recovery.
30	31657	E. C. B. 69 years	3/1/13	Hypertrophy prostate Suprapubic for drainage 3/14/13	140	3/5/13 3/8/13 3/10/13	41 35 35	3% 14% 17%	10% 15%	3/11/13 1.3 3/18/13 2.0	4585 3/11/13 5480 3/18/13 5025 3/19/13	21.9 35.6 30.2	.54 3/10/13		
31	31670	G. N. 66 years	3/7/13	Cancer prostate	140	3/8/13	14	48%	17%	3/12/13 3.3	1555 3/12/13	13.9 11.9	.61 3/11/13		Prostatectomy operation. Blood urea, .470 gms. per liter. Recovery.
32	31705	R. F. 71 years	3/12/13	Cancer prostate		3/9/13	11	33%	27%	3/19/13 2.5	2320 3/19/13	23.3	.60 3/19/13		Prostatectomy, 4/2/13. Blood urea, .222 gms. per liter. Recovery.
33	31782	W. H. D. 48 years	3/24/13	Hæmaturia		3/22/13 3/25/13 3/26/13	10 10 2½	38% 43% 1st. 15 min.	12% R.15 L.18	1.7	1830 3/24/13	6.4 11.9	.59 3/25/13	Negative 3/25/13	No operation. Blood urea, .230 gms. per liter.
34	31824	C. K. 65 years	3/28/13	Hypertrophy prostate		3/30/13	19	trace	trace	4.8 3.3	1575 4/9/13	9.5 4.4	.61 .59 4/8/13	Negative 4/9/13	Prostatectomy.
35	29319	J. T.	2/23/12	Cancer prostate	155	2/26/12	9	15%	18%					8 hours	
36	31779	G. H. 35 years	3/21/13	Double polycystic kidney	150	3/28/13	10	20%	16%	1.7	1260 4/2/13 800 4/9/13	12.6 4.4			Went home.

	Surg. No. Case	Name	Date admitted	Diagnosis	B. P.	Date	Phthalein			Diastase $d\frac{38°}{30'}$	24 Hour Amount cc.	Urine Urea grams	Cryoscopy	Lactose	Remarks
							Appear minutes	1st Hr.	2d Hr.						
37	31890	A. H. 53 years	4/6/13	Hypertrophy prostate		4/8/13 4/20/13	33 14	16%	11%	3.3	1860 4/12/13	*15.4*	.61 4/9/13	4/9/13*	Blood urea, .350 gms. per liter. 4/9/13.
38	31878	J. F. N. 59 years	4/4/13	Hypertrophy of prostate	115	4/10/13	10	trace	7%				.52 4/19/13		Blood urea, 2.17 gms. per liter. 4/19/13. Sent home.
39		B.	5/15/13	Bilateral pyelonephritis			12	12%	18%		4000	4.0		Negative	Iodid 48 hours.
40	32020	J. F. 61 years	4/23/13	Hypertrophy prostate		4/21/13 4/27/13	20 12	11% 25%		5.0	4335 4/29/13	*15.2* 13.0	.59 4/29/13	1st hr. pos 9th & 10th pos.	Prostatectomy, 5/2/13. Blood urea, .198 gms. per liter. Recovery.
41	32048	L. D. 70 years	4/28/13	Carcinoma prostate Vesical calculus		4/29/13 5/2/13	16 15	23% 40%	10% 14%				.57	1st & 2d hrs. pos. 5th & 6th pos.	Prostatectomy, 5/2/13. Blood urea, .450 gms. per liter. Recovery.
42	31998	J. L. 53 years	4/21/13	Carcinoma prostate Resid. urine, 450 cc.	170	4/21/13 4/27/13	[illegible] 20	12% 34%	5% 8%	5.0	2040 4/30/13	*19.88*	.54 4/29/13	1st 4 hrs. pos.	Prostatectomy, 5/2/13. Recovery. Blood urea, .350 gms. per liter.
43	Not indexed	H. 55 years	6/1/13	Vesical calculi stricture		5/22/13 5/28/13		trace trace	trace trace				.60 .66		Blood urea, 1.50 gms. per liter. 2.64 gms. per liter. Dead.

Urea in urine indicated by *italics* was determined by Marshall's method.

* First hour negative; second hour positive; third and fourth hours positive; other eight negative.

These give information of but little value. Patients with very low renal function and advanced disease frequently excrete larger amounts than those in good clinical condition and with comparatively good renal function. When, however, there is a persistently very low urea elimination, it indicates a severe grade of renal disturbance.

In utilizing the second group of tests, viz., tests of retention, a consideration of what is to be accepted as the normal limit seems advisable. Although Folin and Denis [1] accept 0.28 gm. urea per liter as the normal, where no dietary control is exercised in health or in many diseases without recognizable renal changes much higher values are encountered. From our observations it seems advisable to place the limit of normal at 0.55 for urea, and 0.50 gms. per L. total incoagulable N and −.60 for the freezing point. Evidences of retention greater than this are referred to as cumulative phenomena.

Cryoscopy has been employed in 34 cases, 43 determinations having being made. Variations from −0.48 to −0.71 were encountered. In every instance except one a normal phthalein has been associated with a normal freezing point. In this case, No. 31, δ was −0.61 with a phthalein practically normal, 48 per cent for 1 hour. The urea was close to the higher limit of normal, 0.47 gm. per liter.

The highest δ (−0.48) occurred in a man who was being continuously forced to drink large quantities of water.

Nine cases showed cumulative phenomena in that they had a δ lower than −0.60. Except in the case, No. 31, already mentioned, renal function was seriously involved in each instance, as indicated by phthalein and the general clinical condition.

A decrease in phthalein output of serious import may be associated with a normal δ. In a group of 4 cases, Nos. 5, 22, 38, and 43, a trace or less than 10 per cent phthalein was excreted in 2 hours, but the freezing points were normal. These cases were all seriously ill clinically and in the only two cases, 38 and 43, in which blood urea was determined, it was found to be abnormally high, 2.17 and 1.50

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[1] Folin and Denis: J. Biol. Chem., 1913, xiv, 29.

gms. per L. respectively. Repetition of tests 5 days later showed in Case 43 a δ -0.66 and a urea 2.64 gm. per L. This patient died in uræmia, while in the other case operation was refused and the patient sent home on account of his poor general condition.

Blood urea was determined in 12 cases. In every instance in which the phthalein was high the blood urea was normal. Abnormally high urea content was encountered in four instances only, Cases 7, 27, 38, and 43, in all of which the phthalein was low. In Cases 38 and 43, urea was a better index to the renal condition than the cryoscopy, which, as has been pointed out, gave normal values. It would therefore appear that the urea may afford indications of cumulative phenomena earlier than the cryoscopy.

In no instance was a normal blood urea associated with markedly decreased phthalein. Case 37, however, with 27 per cent phthalein for 2 hours showed 0.35 gms. urea per L., while the δ was -0.61.

From a consideration of these data it appears that our previous claims in relation to the value of phthalein were well founded. The phthalein undoubtedly affords the truest index of the functional capacity of the kidney in this group of cases. In no instance was its findings incompatible with the clinical condition and subsequent history. Corroborative evidence only was adduced from the employment of the other tests, particularly valuable in this connection being the presence of cumulative phenomena. In several instances, however, the tests of retention failed to indicate the serious nature of the renal change, so that the findings of these tests can only be considered of great value when marked retention is indicated. The almost constant suppression of lactose in these cases, although rendering the test useless, is an interesting phenomena. From the standpoint of explanation, this is worthy of investigation. Urinary diastase and urea are of about equal value and are unreliable indices to renal functional capacity generally, but where very low values are persistently indicated they have some prognostic significance.

Cumulative phenomena do not occur in the presence of good renal functional capacity, and consequently the tests are unnecessary where the phthalein is normal. They do not occur constantly or early in presence of even marked renal involvement, and consequently would prove misleading in a certain proportion of cases with phthalein not employed. Positive cumulative phenomena, however, are of the greatest prognostic significance.

CONCLUSIONS

To detect the functional impairment associated with the renal changes consequent upon obstruction in the lower urinary tract, the phthalein affords an indispensable index to the true renal condition. Nothing beyond corroborative evidence is to be obtained from the employment of other functional tests.